Infrared Red Intubation System (IRRIS) guided flexile videoscope assisted difficult airway management

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Abstract: BACKGROUND: Tracheal intubation with a flexible scope is a cornerstone technique in patients with severely difficult airways, but may fail. We report on a technique, Infrared Red Intubation System (IRRIS), that seems to facilitate the identification of the glottis. METHODS: The IRRIS is placed over the patient's cricothyroid membrane and emits blinking infrared light through the patient's skin into the subglottic space. When a flexible videoscope (one that does not filter infrared light) is introduced into the airway, it will display this as a blinking white light emerging from the glottis, retrograde transillumination, showing the pathway to the trachea. We have introduced this as an adjunct when managing our patients with difficult airways. We describe the technique and retrospectively report on the first ten patients where it was used. RESULTS: All ten patients had significant pathology in the airway, radiation therapy, predictors for difficult intubation and/or morbid obesity. In all cases the blinking light was visible during the flexible endoscopy and provided unambiguous identification of the glottis, from a distance. The blinking nature of the light from the IRRIS helped to distinguish it from the reflections in the mucosa that inevitably arise when the mucosa is hit by the light from the flexible scope itself. CONCLUSION: The addition of the IRRIS technique to intubation with flexible videoscopes may be a tool that will make intubation of the most difficult airways easier and may be of special help to the clinician who only rarely uses flexible videoscopes for tracheal intubation.

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File Michael / The blinking light bo Biro Elchi

Blinking light emerging from the glottis
– IRRIS (InfraRed Red Intubation System) to guide video-assisted flexile scope tracheal intubation of the difficult airway

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Introduction

Failure to ventilate and intubate during induction of anaesthesia[1] or during resuscitation remains an important cause of morbidity and mortality.[1, 2] Patients with neck pathology, patients presenting for Ear-Nose-Throat-surgery and obese patients are at a special risk.[1] The use of awake intubation with a flexible scope (also known as "fibre-optic scopes" although they seldom contain optical fibres nowadays, rather a video-camera at the tip instead) is a cornerstone technique for safe airway management in the difficult cases[3], with a unique high success rate in skilled hands.[4] However, even with these techniques there are still failures and equally important, it is difficult to obtain and maintain the necessary skills. Thus, we must strive to develop techniques that can make intubation with a flexible video scope easier, increase the success rate when it is applied and to be of help to practitioners with less routine.

The IRRIS (Infra-Red Red Intubation System) is a small infra-red light source that is placed on the anterior neck, over the patient's cricothyroid membrane or trachea. The IRRIS emits waxing and waning infra-red light through the patient's skin and cricothyroid membrane and into the subglottic space. When subsequently a flexible video scope (one that does not filter infrared light) is introduced into the patients' airway, the video-camera of the scope will display it as a blinking white light emerging towards the scope via the glottis, allowing to identify and follow the right pathway in to the trachea.

We have incorporated this new technique for flexible optical video-scope guided tracheal intubation into our clinical practice and we describe the first 10 patients in whom it was used. Additionally, we review the relevant literature on the use of percutaneous light guided intubation and discuss the future role of IRRIS in airway management.

Methods

Description of the IRRIS device and its application.
The IRRIS device, (Guide In Medical, Nazareth, Israel), is a disposable, non-invasive, electronic, near infra-red/ light emitting device in the size of 3.7x4.7x2cm and weighing 30 grams.

(Figure 1).

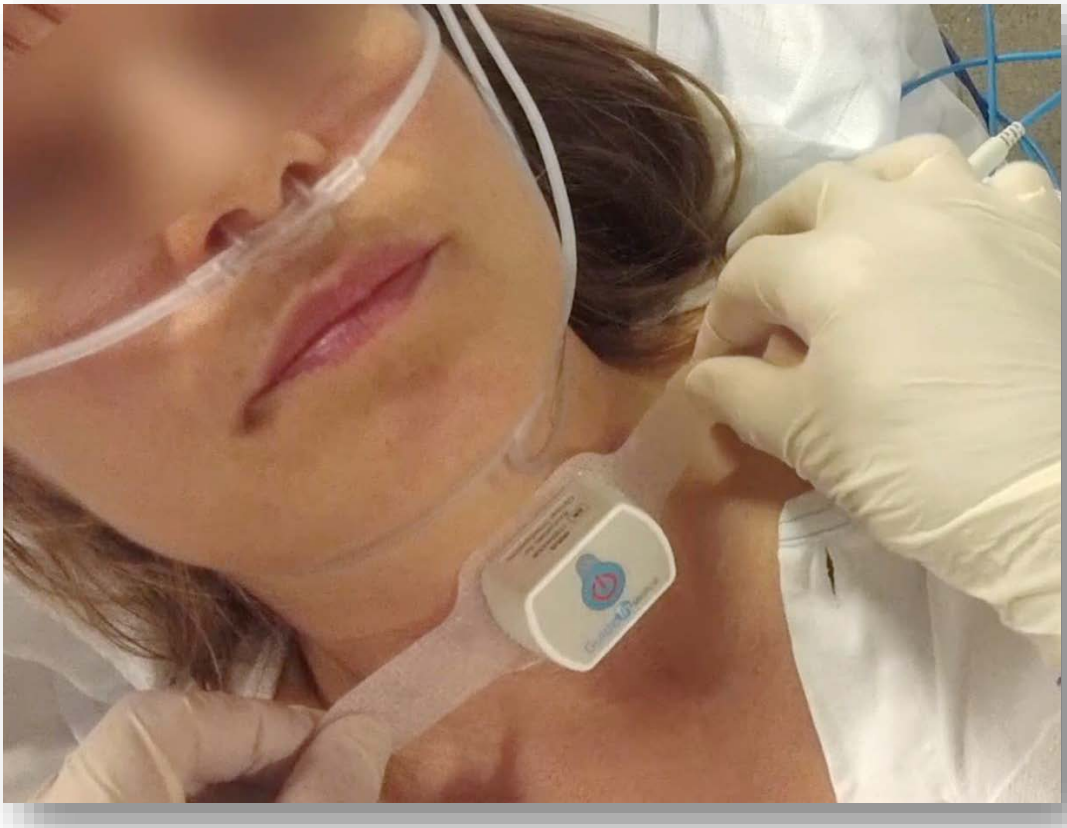


Figure 1:
Legend Figure 1:
The IRRIS device being placed on the anterior neck at the level of the cricothyroid membrane attached with its adhesive tape-stripes.

IRRIS is intended for use as an aid in the placement of an endotracheal tube during intubation procedures performed with video-assisted devices.
Once activated, IRRIS emits a specific near infrared light at a wavelength between 730 -1000 nm. in a waxing and waning intensity for the duration of 10 minutes. The device is placed on the skin of the neck anterior to the airway at the level of the cricothyroid membrane, and fixed by adhesive stripes on both of its sides.

The emitted light penetrates the adjacent tissues of the anterior neck region and into the trachea, and is invisible for the naked eye, but video systems fitted with a camera without an infrared filter can translate it to visible light on the monitor screen.
The image on the screen shows a bright white light shining from within the trachea towards the observer like a beacon. The main purpose of this feature is to guide the intubation by distinguishing the airway from the oesophagus as well as from adjacent structures or mucosal folds that could represent a “via falsa” for an attempted forwarding of a tracheal tube. The assumed benefit of better laryngeal distinction could be relevant in case of unclear, distorted or otherwise complex anatomy, in the presence of blood or overwhelming secretions, or if intubation is performed by less experienced users. After successful completion of laryngoscopy and intubation, the IRRIS device is removed from the neck and discarded. (Please reword this segment because it is wordly identical with parts of the 1st publication. That might cause problems)

Conduct of IRRIS-guided intubation with the flexible video scope
The cricothyroid membrane is identified by inspection and palpation. In case of uncertainty of identification as in case of severe obesity, deviation, pathology, radiation therapy etc., ultrasound can be used for identification of the cricothyroid membrane[5] for correct positioning. The IRRIS device is placed on the skin above cricothyroid membrane (Figure 1) and activated. Local anaesthesia for awake patients or general anaesthesia, is performed as indicated by the clinical needs, and the flexible video scope is introduced via the mouth or the nose. The endoscopy is performed in the usual manner but by using the blinking light seen on the screen (Figure 2) as a guide to supplement the traditional landmark technique or as a replacement for landmarks in the case that they are not recognizable.

Figure 2:

Legend Figure 2:
The iris is turned on (insert) and the light from the IRRIS is seen on the screen emerging from below the vocal cords and is used to guide the advancement of the flexible video scope.

Once the tip of the flexible video scope is in the distal end of the trachea, the tube is railroaded into its final position. Then the flexible scope is removed and ventilation via the tube is initiated. The IRRIS is also removed and discarded.
The IRRIS-guided intubation with the flexible video scope is seen on this ***video*** (click when connected to the Internet, or use this link: *http://airwaymanagement.dk/IRRIS04b)*

We have chosen to include IRRIS into our armamentarium for managing the difficult airway at the section for Anaesthesia for Ear-Nose- and Throat-, and Maxillofacial-surgery, Department of Anaesthesia, Centre of Head and Orthopaedics, Rigshospitalet, University Hospital of Copenhagen, Copenhagen, Denmark and we retrospectively report the ten first cases where this technique was used. Decision to use of a flexible video-scope and for performing awake intubation, or intubation after anaesthesia induction, followed the routine indications and practice of our department.
In the present series, we have used the IRRIS in conjunction with a flexible videoscope (Ambu® aScope™ 3, Ambu A/S. Baltorpbakken 13. DK-2750 Ballerup. Denmark) for intubation of patients with predicted difficult intubation. The awake approach was chosen if there was a coinciding risk of difficulty with mask ventilation or severe pathology in the airway or its vicinity. The video of the intubation was routinely recorded as a part of the procedure. The nasal approach was chosen solely when needed to allow for the surgery to be performed. The video of the intubation is routinely saved.
The patients for awake intubation had local anaesthesia and light sedation according to the routine in our department as previously published[6], supplemented with remifentanil 0.05-0.15 microgram/kg/min and glycopyrrolate 5 microgram/kg. The patients, who were intubated after induction of anaesthesia, had our standard general anaesthesia with fentanyl, propofol and remifentanil-infusion 0.4 – 0.6 microgram/kg/minute preceded by a bolus of 4-5 microgram/kg.

Statistics
95% confidence interval of the binominal distribution was calculated for the outcome parameters (frequencies).

Ethical considerations
The IRRIS is CE-marked for clinical use and introduced as part of our armamentarium for difficult airway management. Formal ethical committee approval was not sought and data were collected as part of delivering standard care. All patients gave oral and written consent to have their data and photos/videos used for publication.

Results

We report our findings from the first ten cases in whom we used the IRRIS to guide flexible optical video-scopic intubation in patients with predicted difficult airways. In all ten cases, 10/10=100 % (69-100%) (95 % CI), the blinking light was visible during the flexible endoscopy, and in all ten cases, 100% (69-100%) (95 % CI), the blinking light provided unambiguous identification of the glottis, from a distance. The demographic details, airway examination and pathology and details of the airway management are all listed in Table 1.

Table 1 near here.

Seven of the patients had significant pathology in the airway including sequelae after radiation therapy. Six of the patients were intubated awake and 6 of the patients had their trachea intubated via the oral route, while other four had tracheal intubation by the nasal route.
In figures 3 and figure 4 we show pictures taken from the flexible scope showing the airway of each patient at various distances from glottis and with various degrees of airway distortion. For each patient, there is an image taken during the two phases of blinking light from the IRRIS, one image *taken in the phase of the blinking where minimal infrared light is emitted and the corresponding image taken in the phase of maximal intensity of the infrared light being emitted.* Thus figures 3 and 4 show the static difference between light and no light coming from below the glottis. The additional benefit of the *blinking* itself, is best seen on the video of each endoscopy/intubation recorded from the flexible video scope. The videos are available individually by the links placed below figures 3 and 4. Additionally all links are available by clicking this ***Patient # 1-10*** when connected to the Internet, or by copying this link to your browser: *http://airwaymanagement.dk/171/index.php?option=com_content&view=article&id=35:irris-movies&catid=2&Itemid=372*

Figure 3 near here
Figure 4 near here

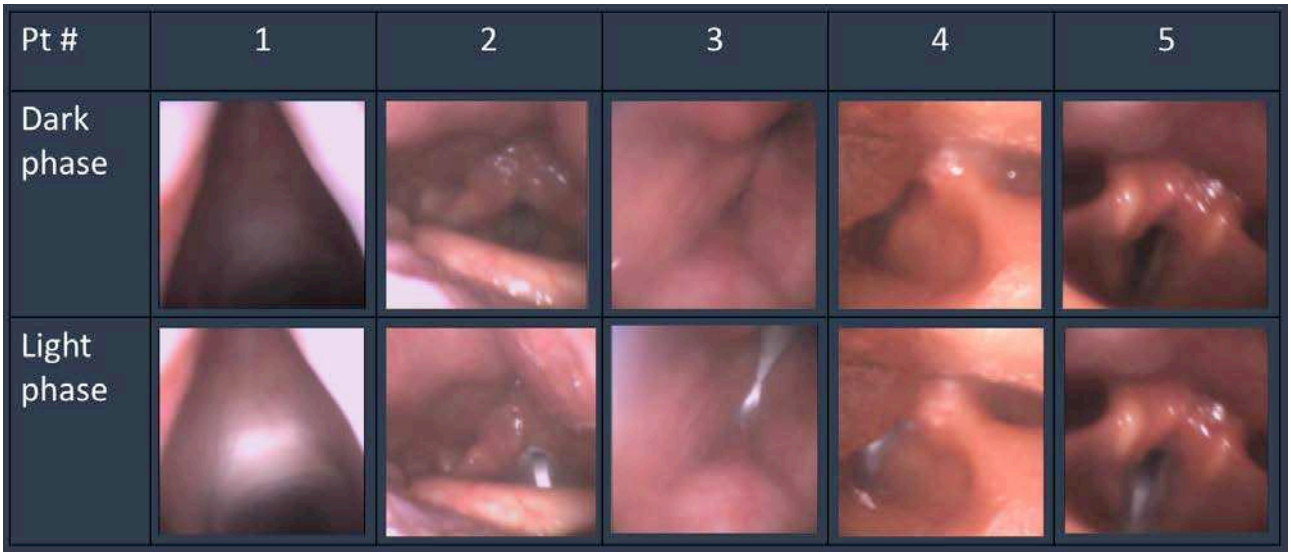
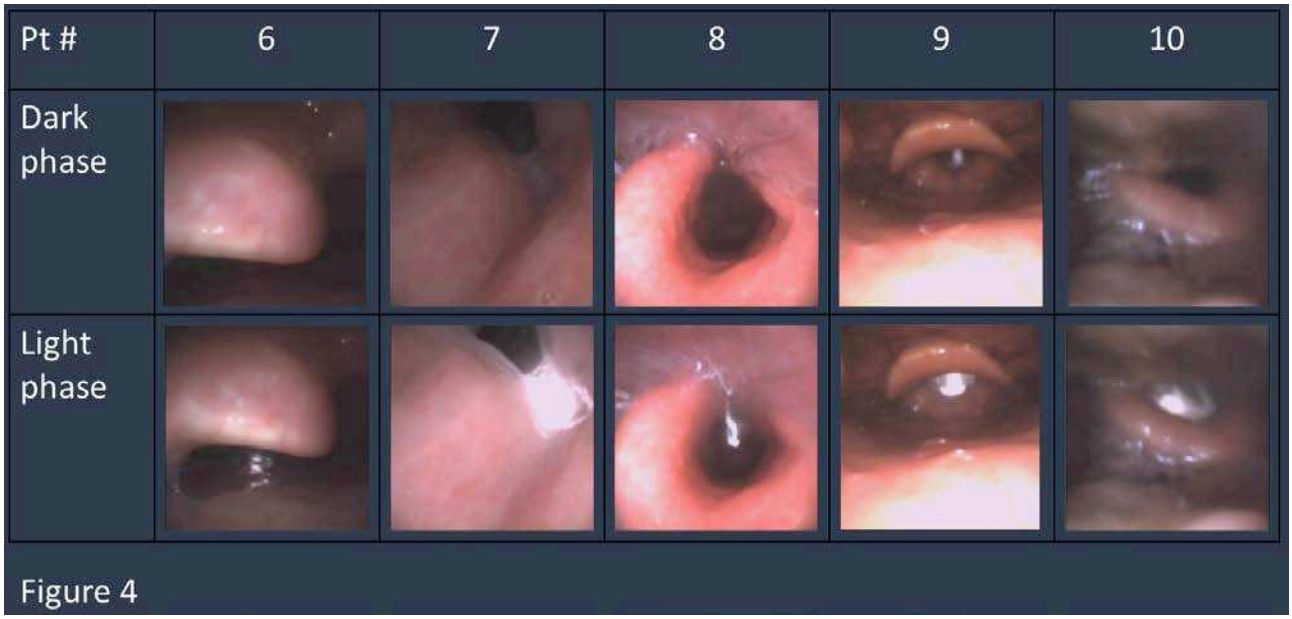


Figure 3.

Legend Figure 3.
Images taken from the video from the flexible scope during the endoscopy preceding the advancement of the tube. The upper shows images taken in the phase of the blinking where minimal infrared light is emitted from the IRRIS device and the lower row shows the corresponding images taken in the phase of maximal intensity of the infrared light being emitted. Photos of Patient #1 display the middle part of the vocal cords and the light coming from the tracheal (=luminal) surface of the cricothyroid membrane. Video here: Patient # 1
Photos of Patient #2 show the view from the oro-pharynx and the light emerging from between the vocal cords. Video here: Patient # 2
Photos of Patient # 3 show the view from the oro-pharynx and the light emerging from between the false cords. Video here: Patient # 3
Photos of Patient #4 show the compressed and displaced airway with light from the glottic opening. Video here: Patient # 4 (a)
Photos of Patient # 5 show the view from the Upper larynx and light emerging from the glottic opening. Video here: Patient # 5



Legend Figure 4. Images taken from the video from the flexible scope during the endoscopy preceding advancement of the tube. The upper row shows images taken in the phase of the blinking where minimal infrared light is emitted from the IRRIS device and the lower row shows the corresponding images taken in the phase of maximal intensity of the infrared light being emitted. Photos of Patient #6 show the view from the oro-pharynx of the epiglottis folded posteriorly and the light from the IRRIS showing the direction to the glottis. Video here: Patient # 6
Photos of Patient #7 show the light emerging from below the anterior commissure between the vocal cords. Video here: Patient # 7
Photos of Patient #8 show light coming from the subglottis and showing the way through the compressed and distorted larynx. Video here: Patient # 8
Photos of Patient #9 show the view from the naso-pharynx and light emerging from between the vocal cords. Video here: Patient # 9
Photos of Patient #10 show the view from the oro-pharynx and the thickened and immobilised epiglottis and light emerging from the trachea. Video here: Patient # 10

In 9 patients, 90 % (56-99% (95% CI) the blinking light was visible already in the oropharynx or above (table 1) and could thus serve as a guide to the upper larynx and downwards once the upper larynx was reached the blinking light was visible in all ten patients (table 1).
It was noted that in all ten patients, 100 % (69-100%) (95 % CI), the *blinking* nature of the light from the IRRIS helps to distinguish it from the reflections in the mucosa that inevitably arise when the mucosa is hit by the flexible scope's own light (table 1).

Discussion

The addition of the IRRIS facilitated identification of the glottis and allowed easy recognition of the pathway to follow with the flexible video-scope in order to access the trachea in all 10 patients with difficult airways.

It is an important finding that the IRRIS worked well in the obese/morbidly obese patients (patient #2 and #5) with a BMI up to 49.5 kg/m^2 (Table 1), as this patient population specifically accounts for a substantial part of the severe morbidity and mortality seen in relation to airway management.[1]

Often the light emitted by the flexible scope will result in disturbing reflections of light in the airway mucosa. The fact that the light from the IRRIS is *blinking* and not constant was found to be helpful (Table 1) to distinguish the guiding -light from the glottis from the reflecting light from the flexible scope.

Several questions remain unsolved and should ideally be investigated before widespread use of the IRRIS: Is the light equally effective if the IRRIS is placed above the trachea as when it is placed above the cricothyroid membrane as we did in the cases presented here? Can inadvertent placement close to oesophagus lead to light coming from the cranial end of the oesophagus? Is there a maximum limit in BMI for its application? How will the technique result in the bleeding or bloody airway? Which brands of flexible scopes can capture the infrared wavelengths and which cannot?

It is a weakness of the present study that it presents a small series and that we have no data to demonstrate if there is an influence on success rate, intubation time or airway trauma between the use of IRRIS guidance or without it. It is a strength that we report on the use in factually difficult patients and that we provide detailed photo and video documentation that allows the reader to fully evaluate the effect of the IRRIS on the image obtained by the video-camera of the flexible scope during intubation.

Previous methods of using light to guide the way to intubation of the trachea.
Light from the inside-out (this term is misleading because it doesn't indicate that it is downward directed as would clearly do my suggested term "anterograde" in this case)
The majority of attempts at using light to guide the way to intubation of the trachea has been by means of a lighted malleable stylet with a light-source at the tip. These "lighted stylets"[7] use visible light that has inferior tissue penetration compared to infrared light and they are introduced via the mouth or nose and subsequently passed via the laryngeal inlet and glottis until the light is seen on the surface of the anterior neck caudal to the thyroid cartilage. By following this light in caudal direction until the light becomes visible at the level of the jugular notch one can deduct that the approximate mid-trachea has been reached, and a tube can be railroaded into position in trachea. These methods can achieve a high success rate in skilled hands[7] but the blind nature of the technique makes it less suitable in case of airway pathology, friable tissue and distortion of the anatomy. Furthermore, these lighted stylets.

Light from the outside-in
(this term is misleading because it doesn't indicate that it is upward directed as would clearly do my suggested term "retrograde" in this case)
A few publications have mentioned the use of visible light applied in the form of a flashlight held towards the skin of the anterior airway at the caudal edge of the thyroid cartilage/at the cricothyroid membrane, during laryngoscopy.[8, 9] This technique was successful in complete novices to laryngoscopy and intubation[9] who performed intubation on patients with *normal* airways and BMI ≤ 30 $kg*m^{-2}$. The technique demands an additional person to hold the flashlight in place.[9]

The previously described methods compared with the IRRIS technique
The visible light techniques either depend on a device that is introduced blindly (the inside-out "anterograde" techniques) or are used solely in conjunction with direct laryngoscopy in patients with easy airways (the outside-in "retrograde" technique) whereas the IRRIS technique works with video-equipped devices and thus is the only one of these techniques that is suitable for intubation of the difficult airways with pathology, tumours and friable mucosal surfaces. It is possible that novices, or practitioners with only little routine, in performing flexible optical intubation would benefit substantially from the addition of the IRRIS device because the findings above,[9] from direct laryngoscopy, indicate that novices seem to benefit very much from having a luminous target to aim at (this last sentence is too long and should be split into two separate phrases).

The placement of IRRIS only depends on the ability to identify the cricothyroid membrane. This is possible in most patients by simple inspection/palpation, otherwise it may demand ultrasound guidance.[5] In four patients, we used a structured ultrasound guided approach because of morbid obesity or displacement/compression of airway structures (Table 1). This structured approach only takes less than half a minute to perform[10] and the time for identification of the cricothyroid membrane is not wasted as the cricothyroid membrane should ideally be identified in all patients with a difficult airway before elective induction of anaesthesia, for the case that they might need an emergency airway access.[11] Before adopting the IRRIS technique, one must assure that the video system allows the detection of the infrared light emitted by the IRRIS device.
In one case (Table 1, Patient #3) the IRRIS stopped functioning approximately 4 minutes after it had been turned on, this happened after the blinking light had served as a guide to the glottis, just when the tip of the scope was to be advanced beyond the vocal cords and thus did not influence the intubation outcome. We could have replaced the device but chose to conclude the intubation without a new one. The manufacturer of the IRRIS must assure the functioning of the device, and we recommend a function time of at least 15 minutes.

The most comprehensive study on airway mishaps to date, the NAP4 study[1], showed that most severe airway mishaps (death, brain damage and emergency surgical airways) could be avoided and that flexible optical intubation was underutilised and should be encouraged. The addition of the IRRIS technique to intubation of the difficult airways with video techniques may be a tool that will make intubation of the most difficult airways with pathology and distortion easier and that it also may be a help to the occasional user of flexible video-scopic intubation. (did you mean with this last semi-phrase the people who only occasionally use FO intubatiuon and are less experienced? If yes, reword it as a separate sentence).

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Acknowledgements

Michael Friis Tvede M.D. Department of Anaesthesia, Centre of Head and Orthopaedics, Rigshospitalet, University Hospital of Copenhagen, Copenhagen, Denmark is acknowledged for advice and for handling the videos.
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Conflicts of interest

Kristensen MS.
No economic interest in any company. Unpaid member of the scientific advisory board for Ambu A/S. Baltorpbakken 13. DK-2750 Ballerup. Denmark

Fried E.
Has been involved in the development of the IRRIS device and is listed as an inventor on the patent. He is one of the founders of GuideIn Medical and the medical consultant of the company. However, he was not involved in the trials' intubations or results.

Biro P.
Biro P. has received travel allowances by Merck Sharp & Dohme and by Acutronic Medical Systems. No conflicts in relation to the present report.

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